Measurements of high-p_T neutral mesons in $\sqrt{s_{NN}}$ = 200 GeV Au+Au and Cu+Cu Collisions at RHIC-PHENIX

Tadaaki Isobe for the PHENIX collaboration

Graduate School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

Abstract. Measurements from the RHIC experiments show strong suppression of high-p_T hadrons in central Au+Au collisions. The PHENIX experiment has observed strong suppression of π^0 and charged hadron yields in central Au+Au collisions for $p_T > 5$ GeV/c regardless of p_T and particle species. The observed suppression is interpreted in terms of energy loss of quarks in a high-density medium.

The PHENIX Year-4 Au+Au measurements have extended the p_T reach of the π^0 spectra to 20 GeV/c. And the PHENIX Year-5 Cu+Cu measurements performed for the study of particle production in a lighter system and they can provide the system-size dependence of the suppression. The suppression patterns of π^0/η at high p_T are presented for each collision system (Au+Au/Cu+Cu).

Keywords: Jet quenching, neutral pion, Relativistic heavy ion collisions
PACS: 25.75.-q

INTRODUCTION

The PHENIX experiment [1] has been carried out at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory to find evidence of phase transition from normal nuclear matter to Quark Gluon Plasma (QGP). QGP is a new phase of matter consisting of de-confined quarks and gluons. One of the most exciting results to date at RHIC is that the yield of π^0 at high transverse momentum (p_T) in central $\sqrt{s_{NN}}$=200 GeV Au+Au collisions is suppressed compared to the yield in p+p collisions scaled by the number of underlying nucleon-nucleon collisions [2]. As there is no suppression in d+Au collisions [3], the phenomenon is interpreted as a consequence of jet-quenching effect, that is, hard-scattered partons produced in the initial stage suffer large energy loss while traversing the dense matter.

In order to understand the characteristics of the energy loss mechanism more, the study of the system size dependence and the comparison between different particle species are important.

NEUTRAL MESON MEASUREMENT AT PHENIX

The PHENIX electromagnetic calorimeter (EMCal [4]) is used to measure γ energy deposit and reconstruct the invariant masses of π^0 and η via 2γ decay mode.

Nuclear modification factor

The amount of suppression can be quantified by nuclear modification factor (R_{AA}). R_{AA} is the ratio of the measured yield to the expected yield from p+p result, and is defined as follows:

$$R_{AA}(p_T) = \frac{d^2N_{AA}/dp_T d\eta}{T_{AA}(b) d^2\sigma_{NN}/dp_T d\eta}, \quad (1)$$

where the numerator is invariant π^0 yield in unit rapidity and denominator is expected yield in p+p collision binary scaled by the number of underlying nucleon-nucleon collisions ($T_{AA}(b)$). $T_{AA}(b)$ is defined as $T_{AA}(b) = N_{coll}(b)/\sigma_{NN}$, where $N_{coll}(b)$ is the average number of binary nucleon-nucleon collisions determined by the distance b between the center of two nuclei with the inelastic cross section σ_{NN}.

Nuclear modification factor of π^0 and η up to very high p_T

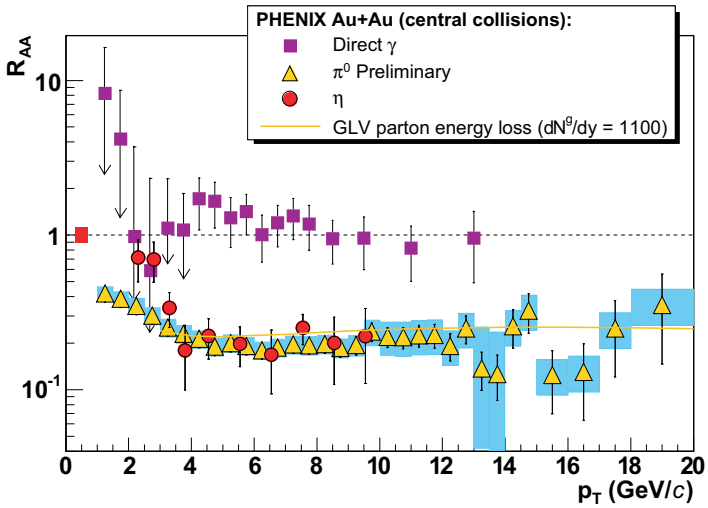

FIGURE 1. Nuclear modification factor, R_{AA} of π^0 (triangles), η (circles), and direct photon (squares). In addition to the statistical and p_T-uncorrelated errors, point-to-point varying systematic errors are shown on the data points as boxes. An overall systematic error of T_{AA} normalization is shown at 1.

Figure 1 shows the preliminary data of π^0 R_{AA} as a function of p_T with finalized Year-2 η, direct photon R_{AA} in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, and theoretical prediction which employs the GLV model [5]. PHENIX Year-3 π^0 data is used as p+p reference for binary scaling. As a result, it is observed that strong π^0 suppression by a factor of ~ 5 and it stays almost constant up to 20 GeV/c. This indicates even a 20 GeV/c pion losses their energy. Also the suppression pattern of η is found to be similar to that of π^0, and this fact supports that the suppression occurs at partonic level. The GLV model describes the strong suppression well and it indicates existence of bulk matter where initial gluon density (dN^g/dy) is more than 1100 in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

Comparison of R_{AA} in Au+Au and Cu+Cu collisions

Figure 2 shows the comparison of R_{AA} in Au+Au collisions to that in Cu+Cu collisions. As shown in right panel of Fig. 2, R_{AA} in Au+Au collisions is very similar to that in Cu+Cu collisions at the similar number of participant. Furthermore, integrated R_{AA} as a function of the number of participant (N_{part}) in Au+Au collisions is very similar to that in Cu+Cu collisions as shown in the left panel of Fig. 2. The model where energy loss depends on path-length in pure dense matter describes data well [5].

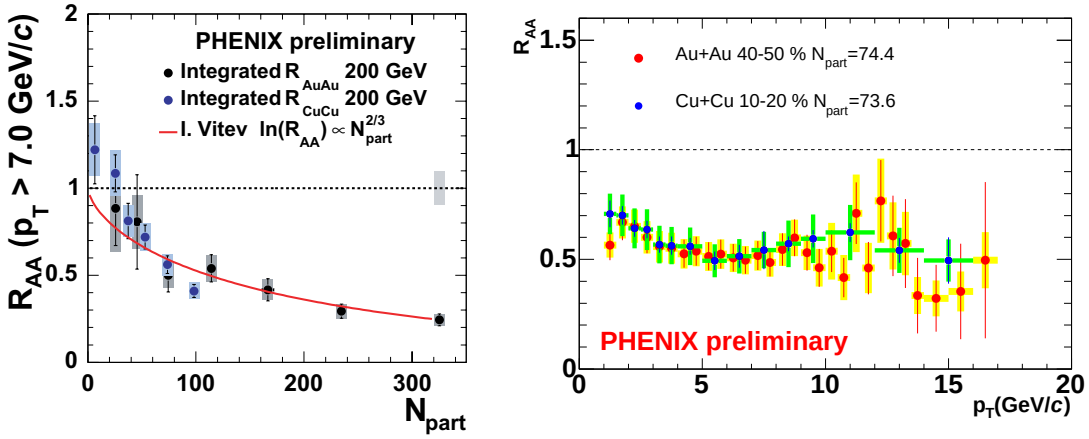

FIGURE 2. Left: Integrated R_{AA} as a function of the number of participant. Right: Comparison of R_{AA} between Au+Au and Cu+Cu at the similar number of participant ($N_{part} \sim 74$).

SUMMARY

π^0 and η are measured in $\sqrt{s_{NN}}$ = 200 GeV Au+Au and Cu+Cu collisions at high-p_T. Strong π^0 suppression by a factor of $\sim$ 5 is observed and stays almost constant up to 20 GeV/c in Au+Au collisions. The R_{AA} comparison in Au+Au and Cu+Cu collisions indicates that the suppression is almost same for similar N_{part}. The universal N_{part} scaling of R_{AA} reconstructs the data well.

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